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The impact of schistosomiasis among rural populations in Liberia[3]

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Summary

Human infection with *Schistosoma haematobium* and/or *Schistosoma mansoni* is known to be widespread in central Liberia, but no information is available about its clinical manifestations or its significance for public health. Details of a cross-sectional morbidity study are reported. A sample from hospital out-patients and samples from 3 villages situated in areas with different transmission patterns (lack of transmission, transmission of only *S. haematobium* and transmission of both *S. haematobium* and *S. mansoni*) were examined. All 184 individuals were examined by standardized case history, clinical and parasitological investigations, including a skin snip for onchocerciasis and a count of schistosomal and other intestinal worm eggs from stool and urine. A complete blood count, urine analysis, urine cultures, hepatitis-B surface antigen determination and abdominal X-rays were also carried out. Schistosomal egg counts ranged from 1 to 6200/10 ml urine for *S. haematobium* and from 1 to 228/g stool for *S. mansoni*. Difficulties for the definition of accurate morbidity indices are discussed. Except for haematuria and dysuria, the overall morbidity in the study area was not striking, neither for *S. haematobium* nor for *S. mansoni* infection. No cumulative pathology was observed in patients with mixed infection. The frequency of hypertension, hepato- and splenomegaly, ascites and bacteriuria was low and no relationship to schistosomiasis could be established. Bladder calcifications were found in 10% of people living in an area of transmission of *S. haematobium*. Although the intensity of infection is low for both *S. haematobium* and *S. mansoni*, long-term follow-up studies are essential for a more accurate assessment of the public health importance of these parasites.

Key words: morbidity; *S. haematobium; S. mansoni;* Liberia.

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Introduction

Human infection with *Schistosoma haematobium* and/or *Schistosoma mansoni* are common in many parts of Liberia, but there are remarkable regional differences. There is much evidence that in central Liberia (Bong County) the transmission and the prevalence of schistosomiasis are the highest in Liberia, whereas no transmission occurs in the costal belt (Miller, 1957; Saladin et al., 1980; Dennis et al., 1983).

There is no doubt that *S. mansoni* and *S. haematobium* can cause marked pathology within the human body (Spencer and Gibson, 1973). This has been shown mainly with studies performed with selected groups such as hospital patients (by among others: Lehman et al., 1973; Salih et al., 1979). As most patients with severe symptoms seek medical assistance such studies are biased and do not reflect the real degree of morbidity in an infected but mainly asymptomatic population. Although the various pathological manifestations of schistosomiasis have been widely described great difficulties exist for the proper assessment of the disease and its sequelae as a result of the lack of appropriate morbidity indices.

An evaluation of the morbidity in a non-selected population is also essential for a more precise assessment of the public health importance of schistosomiasis. Such data must be available to health planners and government agencies *before* promoting control measures on a large scale. They are also important in regard to a possible spreading of the infection as a result of developmental activities. Agricultural development, especially swamp rice cultivation, is promoted in Liberia by the World Bank, US AID and the government.

The aim of the present study was to evaluate the impact of schistosomiasis on the health condition of an unselected population by the simple means available in a field laboratory and a rural hospital in an endemic area. For this purpose morbidity indices were defined which ought to reflect the disease as well as possible, e.g. splenomegaly, bladder calcifications, bacteriuria, hypertension and anemia.

Bong County was chosen for our study, because: – in this area the prevalence of schistosomiasis is probably the highest in Liberia (Miller, 1957; Dennis et al., 1983) and – data about snail distribution, transmission pattern, prevalence and intensity of the infection were already available (Saladin et al., 1980; Sodeman 1973, 1979).

The study was a part of an epidemiological research project, which served to provide accurate information to the Liberian health authorities about malacological, epidemiological and morbidity aspects as well as about appropriate control measures.

Study Area and Population

Our investigations were carried out in Bong County from October 1980 to January 1981. About 200 000 people or 13% of the Liberian population live in this area, with an average population density of 150 persons/km^2.

On the basis of previous surveys (Saladin et al., 1980), we selected for the study subjects sampled from 3 villages and a group from the out-patient department (OPD) of the Phebe Hospital in Suakoko. *Flehla* is a village situated in an area without transmission. The few cases of schistosomiasis there are assumed to be imported. In *Zeansue* only *S. haematobium* is transmitted and in *Synea* both *S. haematobium* and *S. mansoni* are transmitted. A pilot study revealed the following infection rates in school children for *S. haematobium* and *S. mansoni*, respectively: Flehla (n = 49): 8.2% and 4.4%, Zeansue (n = 44): 64.4% and 4.6%, Synea (n = 58): 50% and 64% (Saladin et al., 1980).

A population of 700 is estimated to live in Flehla. In the two other villages a census was carried out by us. In Zeansue 649 and in Synea 1385 persons have their permanent home. In Zeansue 23% and in Synea 28% of the population were between 15 to 30 years old, with a male/female ratio of 0.61 : 1 and 0.74 : 1, respectively. About 60% of the population in Bong County belong to the Kpelle tribe.

The availability of health facilities is different for each village. Flehla has its own dispensary run by a mission and from Synea people can easily reach the Phebe Hospital in Suakoko on foot. No health services are available in Zeansue. Phebe Hospital – the only hospital within a radius of 100 km – is 60 km from Flehla, 30 km from Zeansue and 5 km from Synea.

There was no evidence for differences in nutritional habits between the 3 villages. Staple foods are rice and cassava, which is eaten together with minced and cooked green leaves and palm oil. The main non-imported protein source is fish. Bread is mainly eaten by Mandingos.

Other diseases such as onchocerciasis are also endemic in Bong County (Frentzel-Beyme, 1975). The epidemiological status of malaria transmission is considered to be holoendemic. About 20% of the population are hepatitis-B surface antigen (HB_sAG) carriers (Neppert and Gerlich, 1979; Skinhoj, 1979). The prevalence of sickle cell trait in people from the Kpelle tribe is 23% (Simbeye, 1979).

The study area is described in detail elsewhere (Dennis et al., 1983; Saladin et al., 1983).

Material and Methods

Population sampling

In Liberia, infection with schistosomiasis occurs mainly in childhood, with a peak of egg excretion between the age of 5 and 15 years (Saladin et al., 1980, 1983). As chronic symptoms develop after a delay of several years it was decided to investigate subjects between 15 and 30 years of age.

On the basis of a census, performed in the same year by us, random samples were selected in Zeansue and Synea with the help of a table of random numbers. The sample from Zeansue consisted of 48 individuals and that from Synea of 51 individuals selected at random. In Zeansue the sample represented 19% and in Synea 10% of the corresponding age group. The male/female ratio in the samples (Zeansue 0.42 : 1; Synea 0.89 : 1) reflects that of the whole age group. 4 non-randomly selected subjects, 2 from each village, were also investigated.

Flehla served as a control village. 30 persons mainly women, were selected by the town chief. This is the reason that women are over-represented in this sample.

During 3 weeks 51 patients from the OPD of Phebe Hospital with suspected schistosomiasis were referred to us by the hospital laboratory for further investigations.

In total we examined 184 persons. The patient compliance was excellent and all selected subjects agreed to the protocol. The subjects were carried to the hospital for the examination. No subject received an indemnity, except a free lunch and treatment if necessary.

History and physical examination

Standardized questions were put to all individuals. The interviews were carried out with the help of a questionnaire by two trained and Kpelle speaking Liberian assistants. The subjects were especially asked about hematemesis, urinary symptoms such as hematuria, dysuria or pollakisuria and the number of bowel motions the previous day.

Anthropometric data were collected. Height was measured barefoot and weight was measured normally dressed but without shoes on a "bathroom type" scale. Height to weight ratio related to the estimated age was compared with an American standard (Build and Blood Pressure Study, 1959) and the deviation was recorded in percent.

All 184 subjects underwent a physical examination performed by one of us (B. H.). Liver and spleen enlargement were determined in a supine position. The patients were examined in a lying position only if they exhibited signs of insecurity. Liver enlargement was measured in cm and hepatomegaly was considered present if the liver margin was palpable more than 2 cm below the right costal margin in the mid-clavicular line. The spleen enlargement was recorded according to the classification of Hackett.

Blood pressure was measured at the right arm in a sitting position with an anaeroid instrument. A subject was designated as hypertensive, if the systolic *and/or* diastolic pressure (phase V) was equal to or above 160/95 mm Hg. The general condition was estimated, the subjects were checked for ascites, collateral circulation and peripheral edemas. Kidney and abdomen were palpated and recorded if painful.

Parasitological investigations

Stool, urine and skin snips from all 184 subjects were investigated for parasites. Stool samples and urine were collected from each person between 9 and 12 a.m. in disposable covered plastic containers.

Stool samples were stored in a 10% formol-ether solution and examined afterwards by the modified Ritchie formol-ether method described by Knight et al. (1976). The number of *S. mansoni* eggs/g and other intestinal worm eggs were recorded.

Urine samples were examined immediately for *S. haematobium* eggs according to the method described by Olivier (1973). Results were expressed as number of eggs/10 ml.

The egg output of the different groups was expressed as the geometric mean (Xg). Where appropriate, a log $(x + 1)$ transformation was applied, to include non-infected subjects.

Skin snips were taken with needle and blade from the left iliac crest. They were examined after incubation in normal saline solution for 3 h. If no microfilaria emerged after this time, the skin snip was re-examined after a further 3 h period. The results were recorded only as positive or negative, as the skin was not quantitatively removed.

All stool samples were examined by the same person (K. S.), as well as all urine samples and skin snips (B. H.).

Further investigations

Blood for the determination of hematocrit, white blood cell count and eosinophilia was collected from all subjects by finger prick. Serum obtained from venous blood was also collected and frozen immediately at $-20°$ C for further investigations at the Swiss Tropical Institute in Basel. Antibodies against various parasites and vitamin A levels were analyzed. These results will be reported in detail elsewhere (Stürchler et al., 1983).

HBsAG was determined in 105 subjects, 42 of whom originated from Zeansue and 29 from Flehla. HBsAG was measured by ELISA, but for the 29 sera from Flehla a micro-radioimmunoassay was used.

Routine plain roentgenograms (anterior-posterior) were taken in 146 subjects. Pregnant women were excluded. The films were double checked for bladder calcifications and interpreted by trained radiologists in Switzerland.

Urine samples were checked semiquantitatively for *protein* (Labstix, Ames, England) and *hemoglobin* or *red blood cells* (Sangurtest, Boehringer, Mannheim, Germany). Trace or + 1 proteinuria was considered as normal. Hematuria was considered as present if the stick test revealed any hemoglobin *or* red blood cells. For *urine culture* the dip-slide technique with Cled, McConkey and Pseudomonas agar (Urotube, Roche, Basel, Switzerland) was used. After incubation for 24 h, cultures with more than 10^5 colonies were considered as positive. Further analysis of positive cultures was not performed.

Statistical analysis

The results of the clinical and parasitological evaluations were analysed in two different ways:

- All subjects with schistosomiasis were compared with non-infected individuals independent of their origin. They were classified into several groups according to their egg output (see Fig. 1).
- The morbidity independent of schistosomal infection was compared within the 3 villages and the OPD-group.

The statistical analysis was done by the chi-squared (χ^2)- and Student t-test.

Results

122 females and 62 males were examined. The mean age was 25 years, with a range from 6 to 70 years.

Parasitological findings

All 184 subjects were classified into 4 groups according to their type of schistosomal infection. Group I was composed of 40 subjects with *S. haematobium*, group II of 26 with *S. mansoni*, group III of 34 with mixed infection and group IV of 84 without schistosomal infection.

Table 1 shows the mean age and the prevalence of onchocerciasis and intestinal worms in the four groups. The mean age of subjects with *S. haematobium* or the mixed infection was significantly lower than that of the other two groups (t-test $p<0.01$). The male/female ratio is equal for each group. No significant differences were found between the four groups and both sexes for the prevalence of onchocerciasis or intestinal worms. The egg counts ranged from 1 to 6200/10 ml urine for *S. haematobium* and from 1 to 228/g stool for *S. mansoni*. The output of *S. haematobium* eggs (Xg) was significantly lower in the group with the mixed infection than in that with the single infection (t-test $p<0.01$). No *S. intercalatum* eggs were found.

As Fig. 1a shows, most subjects (83% and 85%, respectively) had only a light infection, with egg counts below 500/10 ml for *S. haematobium* and below 50/g for *S. mansoni*. The number of individuals with a heavy egg output was very low, so they could not be analyzed separately. No significant differences could be found statistically among the various categories of intensity, even when those with a high intensity were pooled. Therefore each of the 4 groups had to be analyzed as a whole. The egg output pattern in subjects with the mixed infection is shown in Fig. 1b.

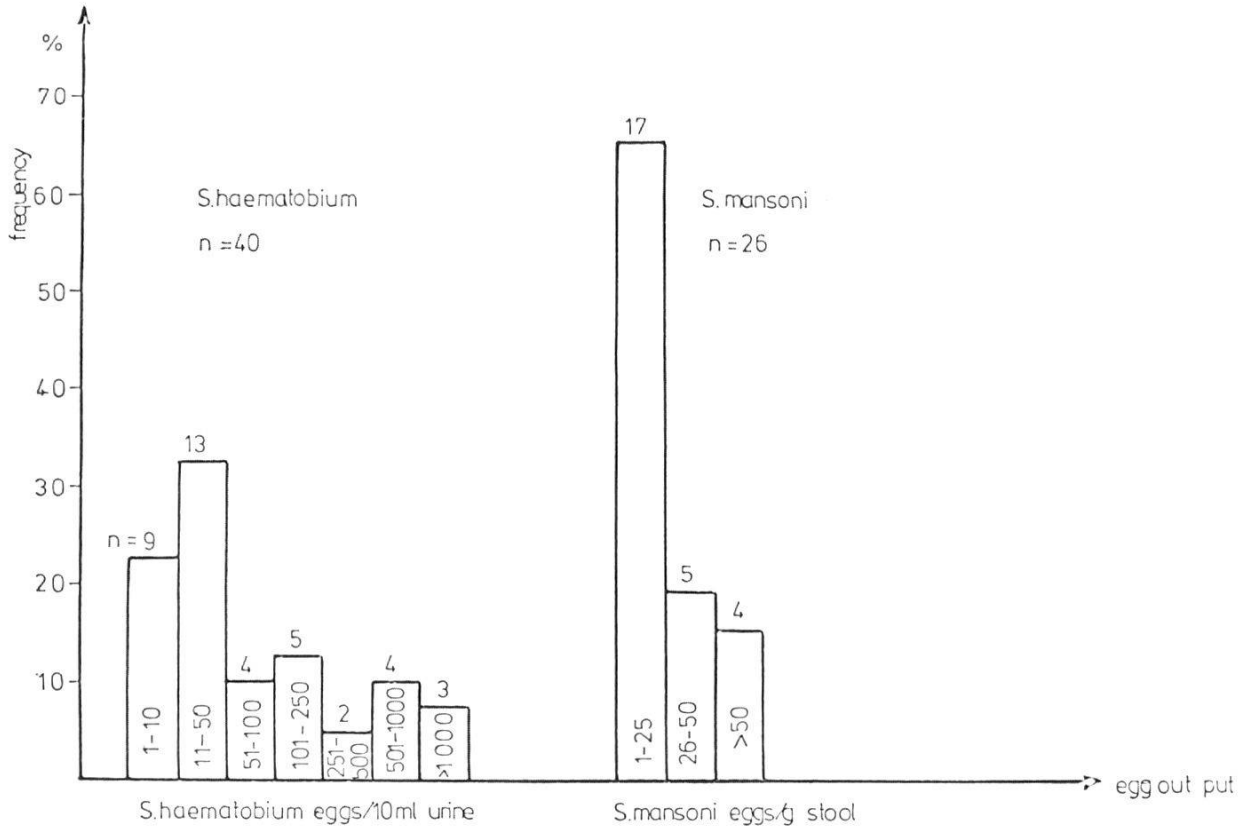

Fig. 1a. Frequency and intensity of *S. haematobium* or *S. mansoni* infections in the study population.

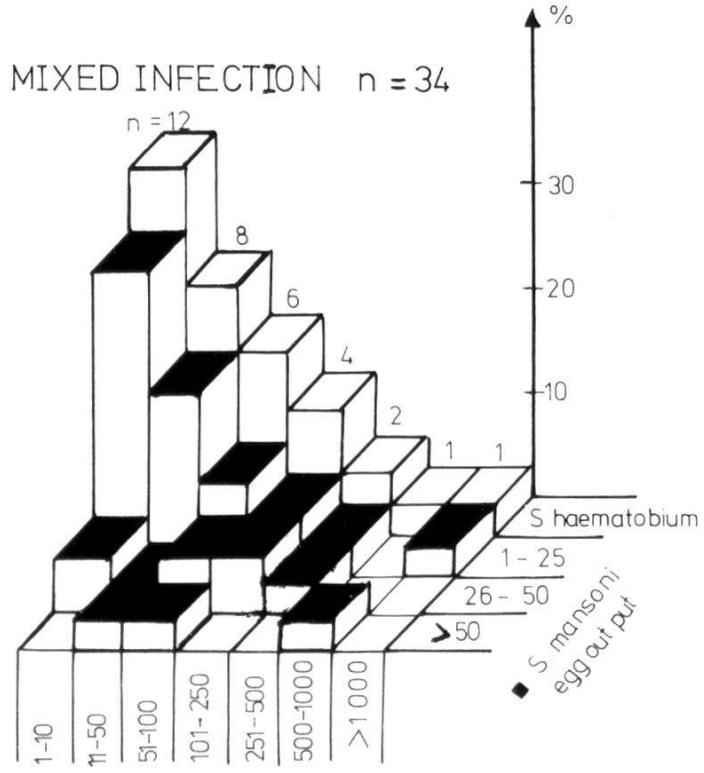

Fig. 1b. Frequency and intensity of the mixed infection with both *S. haematobium* and *S. mansoni* in the study population.

Table 1. Study population and parasitological findings

	All	I *S. h.*	II *S. m.*	III *S. h.* + *S. m.*	IV No infection	Significance level
No. of persons	184	40	26	34	84	
% of males	34	35	27	35	34	NS*
Mean age in years	25 (6–70)	22 (10–70)	28 (15–65)	20 (6–30)	27 (15–60)	$p<0.01$ IV/I, IV/III, II/III** $p<0.05$ II/I**
Height for weight ratio (cm/kg)	3.08	3.56	3.12	3.31	2.99	$p<0.01$ I/IV, I/II, III/IV**
Geometric mean (X_g) log (x + 1) of the egg counts						$p<0.05$ III/II**
S. haematobium		51.7	–	27.7	–	$p<0.01$ I/III**
S. mansoni		–	14.3	12.3	–	$p<0.05$ II/III**
Prevalences of:						
Onchocerciasis (%)	49	58	38	44	50	NS*
Intestinal worms (%)	46	60	50	47	38	NS*
Trichuris %***	22	25	19	24	20	NS*
Ascaris %***	13	15	15	21	8	NS*
Hookworm %***	28	40	15	41	20	NS*

NS = not significant
* = Chi squared (χ^2)-test
** = t-test
*** = total sum gives more than 100% because of polyparasitism
I, II, III, IV = Groups described in the text

S. h. = *S. haematobium*
S. m. = *S. mansoni*

History

Table 2 lists the occurrence of the various symptoms obtained by systematic questioning. More subjects affected by *S. haematobium* (single or mixed infection) than those uninfected gave a history of having passed bloody urine (χ^2-test $p<0.01$). However, no differences could be established statistically for dysuria, pollakisuria, hematemesis or bowel habits. Only 2 individuals complained about hematemesis: A 30 year old women with a very low *S. mansoni* infection (1 egg/g) and a moderately enlarged spleen (Hackett II) and a 6 year old girl with a mixed infection (*S. haematobium* 356 eggs/10 ml; *S. mansoni* 4 eggs/g). This girl was, however, in a good general condition, without hepatosplenomegaly.

Physical findings

The results of the physical examination are summarized in Table 3. Hepatomegaly was found only in 6 subjects, 3 of whom were infected with *S. mansoni* (22–28 eggs/g). Signs of hepatic failure (jaundice, teleangiectasia) were absent. Splenomegaly was common in all groups and was found in 25 individuals (14%), of whom 17 had only moderate spleen enlargement (Hacket I–II). The prevalence of splenomegaly was increased in the group infected with *S. mansoni* (χ^2-test $p<0.05$), but subjects with a *S. mansoni* infection and additional splenomegaly did not reveal a higher egg output than those without. The frequency of painful kidneys and abdomen was equal in each group. None of the subjects suffered from a nephrotic syndrome. Only 1 subject with a unilateral peripheral edema non-related to schistosomiasis was observed. The mean value of the height to weight ratio was found to be significantly higher in groups infected with schistosomiasis (t-test $p<0.01$), but the proportion of subjects with a decrease of the height to weight ratio of more than 10% compared to the standard was found to be equal in the four groups.

X-ray of the abdomen

13 (10%) of 124 subjects originating from areas with transmission of schistosomiasis had bladder calcifications. The youngest individual was a 10 year old girl with a *S. haematobium* egg output of 1312/10 ml. In 4 individuals without *S. haematobium* eggs in the urine, bladder calcifications were also found to be present. The egg output in *S. haematobium* infected subjects ranged from 4 to 1312/10 ml urine with an arithmetic mean of 375. No correlation between bladder calcification and egg output was observed.

Laboratory results

Hematology: Anemia was defined as a hematocrit value of equal or less than 40% for males and 37% for females. 66 individuals or 36% were anemic by this criterion, but only 11 individuals had a severe anemia, with a hematocrit of

Table 2. Frequency of anamnestic symptoms

	All	I *S. h.*	II *S. m.*	III *S. h.* + *S. m.*	IV No infection	Significance level *
No. of persons	184	40	26	34	84	
Hematuria (%)	27	58	15	41	11	$p<0.01$ I/II, I/IV, III/IV*
males with hematuria (%)	26	79	20	16	7	
Dysuria (%)	45	50	40	50	39	NS
Pollakisuria (%)	48	55	38	56	45	NS
Hematemesis (%)	1	0	4	3	0	NS
No. of bowel motions the day before (%):						
2–5/day	26	23	31	24	26	NS
<5/day	5	3	12	3	5	NS

See legend on Table 1

Table 3. Results of physical and X-ray examination

	All	I *S. h.*	II *S. m.*	III *S. h.* + *S. m.*	IV No infection	Significance level
No. of persons	184	40	26	34	84	
Hypertension (%)	6	5	4	9	6	NS*
Hepatomegaly (%)	3	0	12	0	4	NS*
Splenomegaly (total) (%)	14	13	31	15	8	$p = 0.05$ II + III/I + IV*
% with Hackett III and more	4	5	8	3	4	
Hepatosplenomegaly (%)	2	0	4	0	2	NS*
Ascites (%)	2	0	12	0	0	$p<0.05$ II/IV*
Bladder calcification (%)+	7	19	11	8	3	$p<0.05$ I/IV*
Height to weight ratio (mean) (cm/kg)	3.08	3.56	3.12	3.31	2.99	$p<0.01$ I/IV, I/II, III/IV** $p<0.05$ III/II**
Weight more than 10% below standard	34	40	50	32	27	NS*

See legend on Table 1
+ = total X-ray: 146

Table 4. Laboratory results

	All	I *S. h.*	II *S. m.*	III *S. h.* + *S. m.*	IV No infection	Significance level
No. of persons	184	40	26	34	84	
Hematocrit (%) (arithmetic mean)	40.0	40.5	37.6	41.2	39.9	NS**
Anemia (prevalence) (%)	25	15	42	18	27	NS*
severe anemia^{+++} (%)	6	3	15	3	6	NS*
White blood cell count over 9000/mm^3 (%)	11	5	15	12	13	NS*
Hematuria (%)	39	90	15	62	13	$p<0.01$ I/II, I/III, I/IV, III/II, III/IV*
% males with hematuria	9	28	0	15	1	
Proteinuria (%)	15	23	4	32	8	
Proteinuria + hematuria (%)	13	23	4	26	5	$p<0.01$ III/II, III/IV*
Bacteriuria (%)	13	23	8	9	11	NS*
% males with bacteriuria	2	8	0	0	1	NS*
Malaria serology positive (%)$^{++}$	87	83	92	91	86	NS*
HB_sAG positive (%)	18 (n = 105)	17 (n = 29)	17 (n = 6)	23 (n = 13)	18 (n = 57)	NS*

See legend on Table 1

$^{++}$ = IFAT $\geq$ 1:40

$^{+++}$ = hematocrit below 28% for males and below 25% for females

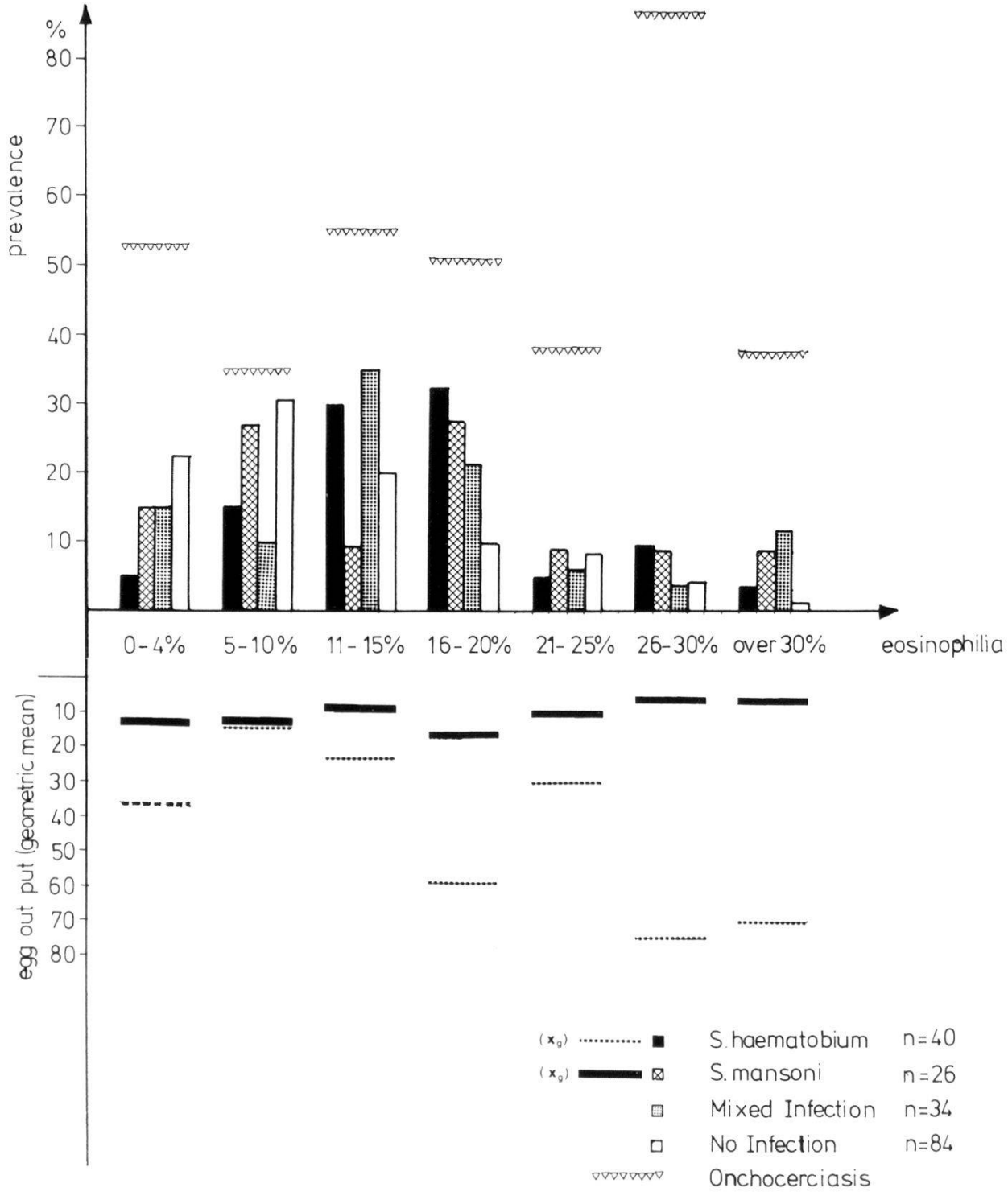

Fig. 2. Eosinophilia in groups with different schistosomal infections in relation to the egg output and to the prevalence of onchocerciasis.

below 28% for males and below 25% for females. In 16 persons anemia was associated with hookworm infection. The percentage of anemic subjects and the mean hematocrit values showed no differences within the 4 groups (Table 4).

A white blood cell count of more than 9000/mm^3 was found in 21 subjects, but without relation to schistosomiasis. 152 subjects or 83% had an eosinophilia

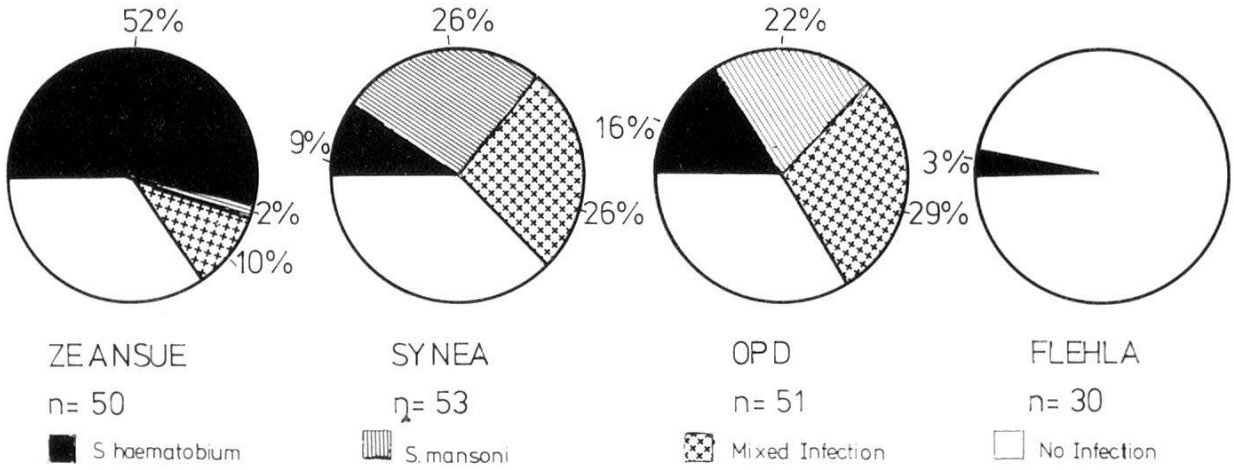

Fig. 3. Distribution of the different schistosomal infections in the 3 villages and the OPD-group.

(over 5% in the thin smear) with a range up to 43%. Presumably because of the influence of polyparasitism, no correlation could be established between the degree of eosinophilia and the intensity of schistosomal infection (Fig. 2).

Urine analysis: Significantly more subjects infected with *S. haematobium* had microhematuria than those uninfected (Table 2). No sex-related differences could be established, but concomitant menstruation was not excluded. No case of macrohematuria was observed. 28 (15%) of 184 subjects had a proteinuria of +2 or more. Only 3 subjects had a severe proteinuria (+3 and more) and 8 subjects with proteinuria had no accompanying *S. haematobium* infection. Because few of the subjects were heavily infected, no relation could be established between the intensity of infection and hematuria and/or proteinuria.

Significant *bacteriuria* was found in 4 men and 19 women. No relation to *S. haematobium* infection could be established. Growth was found only on Cled and not on McConkey or Pseudomonas agar.

HBsAG: It was found positive in 19 (18%) of 105 subjects. The prevalence of carriers did not differ between Zeansue (19%) and Flehla (21%), nor between schistosomiasis infected (19%) and non-infected (18%) subjects.

Analysis of the villages and the OPD-group

No striking, important differences compared to those mentioned above were found between these four groups. The mean age in Flehla (29.3 years) was significantly higher than in the other villages and the OPD-group, because no random sample could be taken. Fig. 3 shows the prevalence of schistosomiasis in the different villages. As expected the prevalence of schistosomiasis was very low in Flehla (only 1 subject positive with *S. haematobium* infection). The prevalence of onchocerciasis was significantly higher in Zeansue (64%) and Flehla (63%) than in Synea (38%) and the OPD-group (37%) (χ^2-test $p<0.05$). In all groups intestinal helminths were found to the same degree, only Zeansue showed a slightly higher prevalence of hookworm infection (36%), compared

with Synea (15%) (χ^2-test $p<0.05$). 7% of the people affected by intestinal worms had triple infection with trichuris, ascaris and hookworm.

History, clinical findings and laboratory results mainly showed differences related to the dominant type of schistosomiasis and not to the locality. In the OPD-group the height to weight ratio was significantly higher than in Synea and Flehla (t-test $p<0.01$), and among OPD patients a higher portion of anemic subjects were found than in Zeansue (χ^2-test $p<0.05$), but no differences could be established for the hematocrit between the 4 groups.

Discussion

Various studies of schistosomiasis related morbidity have been carried out in Africa (Ejezie and Ade-Serano, 1981; Forsyth, 1969; Hiatt, 1976; Lehman et al., 1973; Pope et al., 1980; Rugemalila, 1979; Soyannwo et al., 1978a, b, c; Walker et al., 1970; Warren et al., 1979), but conflicting results have been obtained about the impact on individual or public health. Controversial opinions range from "the crippling sequelae of schistosomiasis with a tremendous economic loss" (Editorial, 1966) to "the lack of significant interference of the parasitosis with general health" (Forsyth, 1968). Although recent studies have demonstrated the connection between schistosomal morbidity and the intensity of infection as reflected in egg counts (Smith et al., 1974; Smith et al., 1979; Warren et al., 1979), the various morbidity patterns cannot be explained by differences in prevalence and intensity alone. How far the morbidity is influenced by other factors such as regional differences in schistosomal strains, susceptibility, nutritional factors, immune status, concomitant parasitism etc. is difficult to assess and remains an open field for further research.

Observations about morbidity cannot be generalized and are usually valid only for the population under review. It is therefore important that the clinical disease is determined by epidemiological, clinical and autopsy studies for each locality.

Only a minority of the exposed and infected population suffers from the clinical manifestations (Elsdon-Dew, 1967; Kloetzel, 1974). Therefore it may be difficult to assess clinically the presence of schistosomiasis as a disease, especially in a population with a low intensity of infection. No simple methods suitable for field conditions are available for the clinical assessment of the health impact of schistosomiasis. General agreement exists today among epidemiologists about the relationship between splenomegaly and the morbidity due to *S. mansoni* infection (Mott and Cline, 1980), but splenomegaly can be misleading in malarious areas. The significance of other possible schistosomiasis related morbidity indices such as anemia, underweight, hypertension, hepatomegaly, bladder calcifications etc. is difficult to assess and may be influenced by many other factors.

The situation is additionally complicated by the biphasic nature of the disease. Morbid effects often appear first in advanced age when the intensity of infection can no longer be determined anymore by simple methods such as measurement of the egg output.

In Bong County the overall morbidity is not striking in our study population, neither for *S. haematobium* nor for *S. mansoni* infections. The low intensity of infection in our study population, with only few heavily infected subjects (about 10% have over 500 *S. haematobium* eggs/10 ml urine and about 12% have over 50 *S. mansoni* eggs/g stool) is associated with few signs of disease; single or mixed infection seems to be well tolerated by the population. Because of the narrow range of intensity, no correlation between worm burden and history, clinical findings or laboratory investigations could be established. Although our population samples can be assumed to represent the corresponding age group in the settlements, the portion of heavily infected people is too low to find subjects with severe pathology.

Although the methodology is not always the same, low morbidity has been observed in other parts of Africa and is reported e.g. from the Ivory Coast (Roux et al., 1980), the Gambia (Wilkins, 1977), Nigeria (Ejezie and Ade-Serano, 1981; Soyannwo et al., 1978a, b, c), Ethiopia (Hiatt, 1976) and South Africa (Walker et al., 1970).

S. haematobium

The functional significance of bladder calcifications is not well known, they are probably without any importance and spontaneous, partial or complete resolution have been reported (Young et al., 1973; Pugh et al., 1979a). The calcifications are nevertheless the clearest sign of *S. haematobium* related morbidity. 13 (10%) of 124 subjects from areas where transmission occurs revealed bladder calcifications. Similar figures are reported from Nigeria (2–23%) (Pugh et al., 1979a; Soyannwo et al., 1978c) but the frequency of calcifications seems to be much higher in Egypt (25–50%) (Lehman et al., 1973; Pope et al., 1980) and in Tanzania (52%) (Rugemalila, 1979). Forsyth (1969) found a low prevalence of bladder calcifications (14%) in Zanzibar, but a high percentage of urological abnormalities by intravenous urography.

Other morbidity indices such as anemia, underweight, bacteriuria and hypertension could not be correlated with *S. haematobium* infection. *S. haematobium* was not primarily responsible for the anemia observed in our study. 73% of the infected subjects showed a microhematuria and 40% had an additional hookworm infection. The blood loss in this way was obviously too small to cause a significant decrease in hematocrit and alimentary and cooking habits may probably have had a compensatory effect. This observation agrees with the findings from Nigeria (Ejezie and Ade-Serano, 1981), from Tanzania (Forsyth and Bradley, 1966) and from South Africa (Walker et al., 1970), but in Kenya *S. haematobium* was found to be related to anemia (Greenham, 1978).

Infected subjects showed an elevated mean of the height to weight ratio compared with non-infected subjects. No reasonable explanations are available for this. Tribal and nutritional factors do not seem to be responsible. Similar observations are reported from the Gambia (Wilkins, 1977).

In Egypt hypertension, bacteriuria and pyelonephritis have been associated with *S. haematobium* infection (Laughlin et al., 1978; Smith et al., 1974), but no such relationship could be demonstrated in most studies from sub-Saharan Africa (Pugh et al., 1979a, b, c; Soyannwo et al., 1978a, b, c). In particular bacteriuria in association with damage in the urinary tract caused by schistosome eggs may produce pyelonephritis and secondary hypertension. In Liberia no figures about the prevalence of hypertension are available, but the overall prevalence of 6% in our study population is similar to or even lower than that reported from other countries in Africa (Akinkugbe, 1972; Bertrand et al., 1976; Pugh et al., 1979c; Soyannwo and Lucas, 1974; Wilkins, 1977). *S. haematobium* infection in Bong County did not appear to be related to hypertension or to bacteriuria, suggesting that chronic pyelonephritis secondary to schistosomal infection is not an important cause of morbidity among 15 to 30 year old adults.

As expected, hematuria was found more frequently in subjects infected with *S. haematobium* than those uninfected. Macrohematuria was very rarely observed in surveys of schools and settlements in Bong County (Saladin et al., 1983). Although about 50% of the *S. haematobium* infected subjects complained of hematuria in their history, no case of macrohematuria was found in our study and the information about passing bloody urine seems to be unreliable.

Conflicting reports exist regarding the importance of proteinuria (Ezzat et al., 1974; Wilkins et al., 1979). Proteinuria is usually regarded as originating from glomerular or tubular defects in the kidney and not from the lower urinary tract (Hodler, 1978). Although protein loosing nephropathy due to *S. haematobium* (Beaufils et al., 1978; Le Bras et al., 1980; Musa et al., 1980) and to *S. mansoni* (Falcao and Gould, 1975) have been described, there is much evidence that here proteinuria originates from the lower urinary tract and is associated with the intensity of infection (Smith et al., 1974; Wilkins et al., 1979). Autopsy studies from Nigeria revealed no link between schistosomiasis and any significant renal disease (Edington et al., 1970). In our study population 20 (27%) of 74 subjects infected with *S. haematobium* exhibited proteinuria, but no relationship could be established between proteinuria and intensity of infection. Similar figures have been reported from Nigeria (Ejezie and Ade-Serano, 1981; Soyannwo et al., 1978a). The significance of proteinuria for the schistosomal morbidity cannot therefore be assessed without a long-term follow-up.

High HBsAG carrier rates in Africa may be due to the transmission of the infective agent by blood sucking arthropods (Dick et al., 1974) or by helminth larvae penetrating the skin or the mucous membranes (Barbotin and Ouadart, 1972). In Somalia a higher HBsAG carrier rate was observed in patients with urinary schistosomiasis than in a control group (Nuti et al., 1979). In our study

population this observation could not be confirmed. There was also no relationship between the HBsAG carrier rate and the infection of subjects with *Onchocerca volvulus* or the presence of a positive malaria serology. The prevalence of HBsAG carriers was 18%, which corresponds to other reports from Liberia (Neppert and Gerlich, 1979; Skinhoj, 1979).

Several investigators have found a direct relationship between the degree of eosinophilia and the egg output, but mainly in areas without other interfering parasites (Gremillion et al., 1978; Hiatt, 1976). Our study population was affected by intestinal worms and onchocercosis to a similar degree as that reported for other parts of Liberia (Frentzel-Beyme, 1975; Stürchler et al., 1980). Because of this polyparasitism it was impossible to establish any correlation between eosinophilia and schistosomiasis.

S. mansoni

Although high morbidity is attributed to *S. mansoni* infections especially in South America (Kloetzel, 1962), there is much evidence that chronic light infection has little clinical consequences. Intestinal schistosomiasis is generally thought to be characterized by abdominal complaints such as diarrhea or abdominal pain even in subjects with light infection (Hiatt, 1976). We failed to demonstrate such a relationship.

A significantly higher rate of splenomegaly was found in subjects infected with *S. mansoni*, but *S. mansoni* infected subjects with additional splenomegaly did not reveal a higher egg output than those without. Usually the frequency of splenomegaly due to malaria is low in adults living in a holoendemic area, and it can be assumed that an excess of splenomegaly rates is due to *S. mansoni* infection, especially if no local variation of malaria transmission occurs. Roux et al. (1980) reported similar findings from the Ivory Coast.

No uniform opinion exits about the relationships between the occurrence and intensity of *S. mansoni* infections and the appearance of hepatomegaly (Roux et al., 1980; Forsyth and Bradley, 1966; Smith et al., 1979). In our study no evidence was found for a higher hepatomegaly rate among subjects with *S. mansoni*. The cause of liver enlargement in the 3 subjects from the *S. mansoni* group and the 3 of the non-infected group is unknown. Liver biopsy, the only way to establish a causal relationship between liver enlargement and schistosomiasis was not performed and the hepatitis markers were not analyzed in these cases. Amebic abscess could be ruled out, because of the negative serology and our X-ray findings.

No cases with ascites were found in the villages; only 3 subjects belonging to the OPD-group suffered from ascites. No history of alcohol abuse was given. Liver cirrhosis was not excluded by biopsy. All 3 patients had a *S. mansoni* egg output below 35/g stool.

Based on the low frequency of hematemesis in the history and the few cases with clinically established portal hypertension, it can be assumed that severe sequelae of *S. mansoni* infection are uncommon in this area.

Mixed infection

Although many subjects especially from Synea and from the OPD-group, were infected with both *S. haematobium* and *S. mansoni*, no cumulative morbid manifestations could be found. No explanation can be given as to why the mean of the *S. haematobium* egg output was significantly lower in the group with the mixed infection. Probably the transmission patterns are different in the two places.

Conclusions

The limitation of such a morbidity study with cross-sectional design must be borne in mind. Only a snapshot of the evolution of schistosomal disease can be taken. Based on our findings we come to the conclusion that both *S. haematobium* and *S. mansoni* infections produce only few clinical manifestations and appeared to be well tolerated by the population in our study area. However, for a more precise assessment of the public health importance of schistosomiasis further studies are necessary. Additionally long-term follow-up studies of subjects with and without clinical manifestations and the use of more sophisticated methods such as radioisotope nephrography (Zahran et al., 1980) and sonography would contribute to the understanding of the natural course of schistosomal diesease and would help to define the position of schistosomiasis in health priorities in Liberia.

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